

CONFERENCES → IMIERIAL AGRICULTURAL RESEARCH CONFERENCE, 1927.

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AGENDA: MEMORANDUM 9.

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PAPERS ON PLANT DISEASES AND  
PESTS.

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Issued by the Organising Committee of the Conference,  
10, Whitehall Place,  
London, S.W. 1.

September, 1927.







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PAPERS ON PLANT DISEASES AND  
PESTS.

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(It is suggested that the Empire Agricultural Departments should co-operate to establish a staff of travelling entomologists for the purpose of studying the parasites of insect pests and of transmitting those parasites to parts of the Empire that need them).

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(It is suggested that an exhaustive investigation of nematode attack under field conditions in the tropics would prove a most valuable subject for research work).

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The following subjects for discussion have also been suggested:

- (a) Insect and fungus pests, methods of control (Rothamsted Experimental Station).
- (b) The Control of White Fly by means of a chalcid parasite (Cheshunt Experimental Station).
- (c) Insect pests of bananas (Jamaica).
- (d) The control of mosaic disease of the cucumber and tomato by means of clean seed (Cheshunt Experimental Station).
- (e) Panama disease of bananas (Malaya and Jamaica).
- (f) The control of Sugar Cane Mosaic and diseases of coconut, coffee and cacao (Jamaica).







## 1. AUSTRALIA: PLANT DISEASE RESEARCH.

Research work in plant pathology is being conducted at several centres in the Commonwealth with varying degrees of intensity depending upon the staff and equipment available. The workers may be grouped under two heads - the pathologists attached to the different State Departments of Agriculture and those on University staffs. The problems investigated range over the whole field of cultivated crops. From the nature of their advisory duties, departmental officers tend to work extensively, while University workers are free to work intensively on a problem or group of problems. In the larger State Departments, specialisation by individual officers is possible.

The chief centres of work are as follows:- New South Wales, Department of Agriculture and the University School of Agriculture; Victoria, the Department of Agriculture and the University Department of Botany; Queensland, the Department of Agriculture and the University Department of Biology; South Australia, the Waite Agricultural Research Institute; Western Australia, the Department of Agriculture.

The problems known to be under investigation may be most conveniently grouped under the crops.

### 1. Cereals.

(a) Rusts. The University of Sydney is conducting a cereal rust survey in Australia, using the methods of Stakman to determine the biologic strains. The number of strains definitely isolated up to the present is small (4). Only one of these agrees with Stakman's described strains of Puccinia graminis tritici in America. Concurrently, breeding experiments are being conducted to develop varieties of wheat and other cereals resistant to the rusts of Australia. Rusts of cereals are most important in the South-east of Australia. In other parts, which have a drier climate, the loss caused is negligible in most seasons.

(b) Smuts. The most serious cereal smut is Urocystis tritici (flag smut); which has been a special subject of investigation by the N.S.Wales Department of Agriculture. Further work is in progress on soil cultural treatments, development of resistant varieties, and the physiology of the causal fungus. Bunt and loose smuts of the cereals also occur in varying degrees of intensity, but are not known to be the subject of special investigation at the moment. It is a practice in some of the wheat-breeding centres to infect the  $F_2$  generation of a cross with bunt spores and thus secure bunt resistant varieties.

(c) Foot-rots. Foot-rot diseases and take-all (Ophiobolus) are probably the most serious group of wheat diseases in Australia at present, and in some States cause more loss than any other cereal-in-festing fungi. They are the special subject of study of two investigators one stationed at the N.S.Wales Department of Agriculture and the other at the Waite Institute, South Australia. The former is dealing with the pathogenicity of strains and their physiology and reaction under controlled condition of moisture at ordinary temperatures. The latter is working more particularly on temperature effects on the physiology and pathogenicity of the organism.

### 2. Fruit Trees.

(a) Citrus. The Department of Agriculture in N.S.Wales is devoting its attention largely to the more serious citrus diseases in that State, viz., Brown Spot (Colletotrichum gloeosporoides), Black Spot (Phoma citricarpa), verrucosis, exanthema, etc.







In Western Australia, the Department has described a new species of Phytophthora responsible for a brown rot. This organism also occurs in South Australia.

On the whole, citrus diseases are more common in the coastal districts than in the irrigated areas which lie in semi-arid districts.

(b) Pomaceous fruits. Black Spot (Venturia) is the most wide-spread disease of apples and pears. Others of importance are Armillaria root-rot, powdery mildew, and bitter pit. An investigator of the Department in N.S.Wales is paying special attention to apple diseases. In many of the apple growing areas of Australia the control of black spot is the most serious problem to be faced, and this is largely a matter of climatic conditions at the time of spraying.

(c) Stone fruits. In the drier parts of Australia stone fruits are remarkably free from disease. Spraying against leaf-curl is a general practice. In parts of Victoria and N.S.Wales brown rot (Sclerotinia) is a cause of serious loss; as are soft rots of the fruits in transport.

(d) Tropical fruits. Diseases of the banana and passion fruit are being investigated in Queensland under the direction of Professor Goddard. Of these the most serious has been Bunchy Top of bananas, which occurs also in N.S.Wales. This has recently been shown to be a virus disease transmitted by the black banana aphid. Squirter disease of bananas is also under investigation.

(e) Insect Pests. Two of the chief insect pests of fruit trees in Australia are the codlin moth and fruit fly. The former has a wider distribution than the latter, which is confined to the eastern portion of Australia and to West Australia. Quarantine authorities are attempting to restrict its spread. Investigations into the control of the insects have also been conducted.

Phylloxera has attacked vines in Victoria and N.S.Wales. It is unknown in South Australia and the irrigation areas of the former State, strict quarantine measures being employed to prevent its spread.

### 3. Minor Crops.

Two minor crops are the subject of special research at the moment owing to the serious losses caused by the diseases affecting them. They are tobacco and tomatoes. The former is seriously attacked by blue mould, the latter by a disease known as "spotted wilt". Research on blue mould is in progress by the N.S.Wales Department of Agriculture and by the Department in Victoria. Both are specially concerned with methods of control in their respective areas.

Spotted Wilt of tomatoes is under investigation in New South Wales, Victoria, and South Australia. In the last mentioned State the Council for Scientific and Industrial Research has provided special greenhouse equipment suitable for investigating virus diseases. The indications are that the disease is of a virus nature, but this has yet to be proved. The means of transmission are as yet unknown, as are the conditions for its epidemic development.

Diseases of peas and hops in Tasmania are being investigated at the Melbourne University.







PLANT PATHOLOGY.

A staff of five plant pathologists is maintained by the Department, with a well-equipped central laboratory in Wellington. It is proposed in the near future to transfer this laboratory to an area of 20 acres of high-class ground at Palmerston North, in the vicinity of the new Agricultural College. For its field work, sub-stations in various parts of New Zealand are to be maintained as at present. Agricultural plant pathology in New Zealand is divided into two main phases:-

- (1) That concerned with farm crops.
- (2) That concerned with fruit crops.

The technical officers of the laboratory are linked up on the one hand with district agricultural instructors, and on the other hand with district orchard instructors. This close co-operation of the laboratory with the instructors tends to make the work of the laboratory of immediately practical application and has been found to tend to reciprocal efficiency. So far as the laboratory work in connection with plant diseases is concerned, great emphasis is given to the necessity of all investigation being properly co-ordinated with accurate systematic and taxonomic work, a feature often apparently of only academic value but in reality in all cases of fundamental practical importance. With orchard diseases the practicability of chemical treatment in the form of sprays has been fully recognised for many years past in New Zealand, and much of the research work has been with the objective of formulating spray schedules applicable for varying meteorological conditions. With regard to most fruit diseases satisfactory methods of control have been worked out; but certain ones, such as silver-leaf, root fungus, fire-blight, and brown-rot, as in other countries, are not satisfactorily controlled. A great deal of research on all these diseases has been carried out, and in the case of brown-rot the application in wet localities of dry dust treatments appears to give a good promise of effective control.

In New Zealand the spray pump and the dust machine are the basic features in the control of disease in orchards and market garden crops; but with field crops, which have a low per acre value, no spraying methods have been found to have any practical application. During the past few years departmental research in field-crop disease control has largely been along the line of seed disinfection. It has been shown that the number of seed-borne field-crop diseases is far larger than is currently supposed, and effective seed sterilization is the most logical method not only of control, but of elimination. Dry-rot in swedes - an extremely bad disease in New Zealand - has been shown to be entirely due to disease in the seed, and a special technique for the treatment of such seed with hot water combined with such a material as Semesan has been shown to be effective and practicable. Certain modifications in hot-water treatment for smut have also been far superior to dusting with copper carbonate or steeping in bluestone or formalin. Complete control has been secured and methods for the complete elimination of smut from cereal districts by the sowing of seed from crops that have been treated are being carried out.







The researches that have been, and are being, carried out on seed-borne diseases give promise of having far-reaching importance, and the majority of work in field-crop diseases is now definitely along these lines.

Club-root in turnips is, in New Zealand, as in many other countries, exceedingly troublesome, and the oft-repeated assertion that lime will sufficiently control the disease has not been borne out in practice in New Zealand. The trial of certain Danish varieties has been only moderately successful and the disease remains more or less uncontrollable here, crop rotation methods being the only ones that are apparently of much value. The fact that liming, even to the amount of 16 tons of carbonate of lime to the acre, has not made infected ground capable of growing a sound crop, is a very good example of how control methods, of value in certain countries, have had no effect here, and emphasizes the necessity of local research into all farm and garden diseases.

It may be mentioned here that, in New Zealand, so far as field crops are concerned, very little plant-breeding research in the production of resistant or immune crops has been carried out, but this line of investigation is now being taken up by the Government; and the plant-breeder working in co-operation with the mycologist is to be made one of the features of the new disease control and plant-breeding laboratory at Palmerston North.

In any consideration of plant pathology carried out by the Government, special mention must be made of the very great use that is made of the Imperial Bureau of Mycology. The co-operation and advice of this institution are invaluable so far as workers in plant pathology in New Zealand are concerned.





### 3. UNION OF SOUTH AFRICA: THE CONTROL OF PLANT VIRUS DISEASES.

#### The problem in South Africa.

In South Africa, as elsewhere, the plant virus diseases represent an important factor in the production of crops. The more important diseases which have up to the present been given attention are the following:-

Mosaic disease of sugar cane and related plants. Steps are being taken towards the eradication of sugar cane mosaic in Natal by the destruction of all varieties which are not immune to this disease. A mosaic of maize and sorghums in the Transvaal causes some loss. The causative virus appears not to be transferable to sugar cane.

Streak of sugar cane and maize. Studies during the past four years have shown this disease to be transmitted by a jassid. Cane varieties of the Pansahi group appear to be particularly susceptible, and the disease causes losses of tonnage of 10 to 20 per cent. Streak in maize occurs widely at altitudes below 4000 feet, and the effect on the plant is very severe. Some measure of control has been obtained by selection and roguing of cane; work is in progress to obtain resistant strains of cane and maize.

Rosette of ground nuts. This crop is in the Transvaal subject to frequent severe loss due to rosette. Work is in progress towards the discovery of resistant strains.

Diseases of the potato. Since seed has for many years been imported from Europe it is likely that the majority of the known virus diseases of the potato are established in South Africa. No research has however yet been undertaken upon this problem.

Diseases of tomato, tobacco and cucurbits. Mosaics are prevalent and also other possible virus diseases. No investigations have yet been prosecuted.

#### Institutions and Staff.

Virus disease research has been carried out primarily at the Natal Herbarium, Durban, with a staff of two mycologists, and incidentally at Pretoria. Schemes for potato certification have been initiated in co-operation with farmers' organisations.

#### Further research.

There is great need for the investigation of the whole virus disease problem from every aspect. In particular it is important that we should know the relation, if any, which exists between the viruses of diseases in different hosts, and the possibility of interspecific transmission of single viruses. The many diseases of single hosts require to be sorted out, and individually studied. Further investigations are needed on the effects of infection by two or more viruses; on the occurrence of symptomless carriers and on the conditions determining the masking of symptoms; on the mechanism of insect transmission and the biology of the insect vectors.

At present our most effective method of control is by the use of resistant varieties. The search for them is probably the work of the greatest economic importance. In this the co-operation of agricultural explorers and plant breeders is needed.





## TRINIDAD & TOBAGO: LINES - WITHER TIP AND RESISTANT VARIETIES.

By W.G.FREEMAN - DIRECTOR OF AGRICULTURE.

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The lime, Citrus aurantifolia Swingle, C.medica var acida, has been grown throughout the Colony for domestic purposes since very early days. Attention was given to it as a crop, the exports of concentrated juice and lime oil reached a value of some £16,000 per annum and there was good promise of future development.

In 1918 Wither Tip or Blossom Blight disease Gloesporium limetticolum Clausen became prevalent in Trinidad and later in Tobago. In Trinidad it was found to be widely spread but in Tobago it was apparently confined to one isolated estate. Arrangements were made to destroy at Government expense all the trees on this estate, and all lime trees in a belt surrounding it, compensation for the latter being paid to the owners. Importation of lime plants and fruits into Tobago was also stopped. The efforts were however not altogether successful.

The impracticability of controlling Wither tip on an ordinary West Indian lime estate by spraying has long been recognized. The lime is in almost constant growth during the wet season and as the disease affects the young foliage the number of sprayings would be too many to be economically feasible. The disease, affecting only a small portion of the leaf area does not kill, nor usually even appreciably weaken the trees, but if its incidence is high during the flowering season a very large proportion of the flowers and young fruit is ruined with consequent loss of crop.

In practice it is found that the incidence of the disease, as judged by the crop, is dependent on favourable conditions, notably high humidity, for its spread during the flowering period, with the result that although the disease is now constantly present, good crops of limes are obtained in some years.

Before being observed in Trinidad the disease had for some years been known in Porto Rico, British Guiana, Cuba and Florida. It has since appeared and done very great damage in Dominica and more recently in St.Lucia. Once introduced it spreads with very great rapidity if conditions are favourable.

The Department of Agriculture has made efforts to find or breed an immune or highly resistant lime, capable of meeting commercial requirements, principally for the manufacture of concentrated or raw juice, and for the green lime trade. The work of collecting was started in 1921 and of hybridizing in 1925. These efforts if successful would also be of value to the other West Indian colonies. The following is a summary of the results so far obtained. The work has been carried on by Mr R.O.Williams, Supdt. Royal Botanic Gardens.

### TRIALS OF INTRODUCED PLANTS.

RANGPUR LIME. Resistant to Wither tip, but subject to Citrus scab and foot rot. Not likely to be of much value. Citrus acid content 9.76 per gal. (Pope Honolulu).

CITRUS PHILIPPINE ISLANDS No.367C. This proved to be the spineless lime, previously here.





CITRUS hystrix. Very vigorous and not yet affected by wither tip. It is slow in coming into fruit. H. Atherton Lee says it should be especially desirable for citric acid production. No use for a green lime trade.

Citrus Everglade Phil.Is.3669. Very susceptible to wither tip. All its flowers are perfect, so that when it escapes infection it produces large bunches of fruits. This floral character may prove of value in breeding and it has been crossed with the following variety.

Citrus aurantifolia Phil.Is.1013. Resembles a small lemon and lacks the true lime flavour; highly resistant to wither tip; fruits very early, within 18 months from sowing the seed. Citric acid content 10.2 oz. per gall. (Hardy). It has been crossed with the ordinary lime.

BURMA LIME. Received from Dr.S.C.Harland. It has proved apparently susceptible to wither tip.

KUSAIE LIME. Not attacked by wither tip, but somewhat susceptible to Citrus scab. It has just begun to fruit. Citric acid content 10.80 oz. per gal. (Pope Honolulu).

Citrus excelsa. Very vigorous, bearing large fruits unsuitable for the green lime trade. Citric acid content only 5.14 oz. per gal. (de Verteuil). Not susceptible to wither tip, but several trees have succumbed to foot rot.

#### HYBRIDS RAISED.

(a) Seedlings of a cross between C.aurantifolia 1013 (male) and the ordinary lime (female) show great leaf variation. Those resembling the female parent are susceptible to wither tip; the others, so far as present observations go, are apparently not. They have not yet fruited.

(b) The cross between Citrus aurantifolia 1013 (female) and Citrus Everglade 3669 (male) have fruited within 18 months of the seed being sown. They have practically all bred true to the female parent. This is probably the result of polyembryony.

The work is being proceeded with and an offer to raise budded plants of the hybrids which promise to be of some value has recently been made to the Agricultural Departments of both Dominica and St.Lucia so that they may be tested in those islands also.





5. CANADA: MEMORANDUM REGARDING RESEARCH  
WORK CARRIED ON BY THE ENTOMOLOGICAL  
BRANCH, DOMINION OF CANADA, DEPARTMENT  
OF AGRICULTURE.

FIELD CROP INSECTS.

Grasshopper Investigations.

These are being conducted in co-operation with the Department of Agriculture and Department of Lands and Forests of British Columbia, in which province a very serious outbreak is present. As a result of investigational work conducted in the prairie provinces during the years 1919-1923, when millions of dollars worth of crops were saved to the farmers, improved poison baits for grasshopper control are now widely used in Western Canada. The officers of the Branch are engaged in studying the life-histories of the western species of grasshoppers so that the young hoppers may be recognised in their early stages.

Colorado Potato Beetle

Owing to the spread of this insect in British Columbia special investigations have been incepted and a campaign of control directed among the growers. During 1926 a detailed investigation into the distribution, life-history and spread of the insect was undertaken in British Columbia, and the Branch is now in a position to make definite control recommendations.

European Corn Borer

A further spread of this insect has taken place during the present year, and in addition to the Province of Ontario being well infested, the borer has also been found in a number of counties in the Province of Quebec. A well trained Entomologist has recently been appointed to make further studies of the life-history and control of this insect, and this officer is stationed at our Chatham, Ontario, laboratory. Further investigations will consist chiefly in re-appraising the value of the control recommendations on an adequate scale; a further study of the relation between date of planting and infestation; appraisal of weeds and barnyard refuse as reservoirs for infestation, and in the annual routine study of the rate of development and mortality throughout the season.

During 1926 the breeding and colonizing of the two main species of European parasites have been conducted. 575,000 adults of Habrobracon brevicornis were liberated in Western Ontario in fields infested by the corn borer, and 65,000 specimens of the parasite Exeristes roborator. In addition to these parasites, through the co-operation of the United States Bureau of Entomology two new species of parasites were received from Europe, which are being reared and as a result of which liberations will be made. Since the development of the parasite laboratory at Chatham, Ont., over two and one-half million individuals of Habrobracon brevicornis and close on to 200,000 specimens of Exeristes roborator have been released.

Cutworm Studies

Cutworm studies are carried on principally in the prairie provinces. The species of cutworms which have been specially prevalent in the prairie provinces during recent years are the Pale Western Cutworm and the Red-backed Cutworm.





Special studies of these have been made. The Red-backed Cutworm in the years 1925 and 1926 caused damage to the grain crops amounting to six million dollars in the Province of Saskatchewan alone. As a result of investigations now being conducted, it is hoped that our officers will be able to foretell outbreaks and advise the farmers promptly as to what practice they should follow to avoid injury.

#### Western Wheat-stem Sawfly

The Western Wheat-stem Sawfly is present in destructive numbers in all three prairie provinces. The insect has been specially investigated in Manitoba, and as a result of studies made at our Treesbank laboratory it is found that the larvae or grubs of the sawfly do not cut the stems of wheat until the plants begin to lose their sap. As a result of this important discovery much grain has been saved by being cut a little on the green side and before the work of the insect caused the stems to fall over.

#### Hessian Fly

This insect has been specially studied in the Provinces of Ontario and Saskatchewan. It occurs intermittently in very destructive numbers. As a result of work conducted in Ontario it is now possible to indicate to farmers of this province approximate fly-free dates for the sowing of fall wheat.

#### White Grubs

These insects, which have a long life-history, have been specially studied in the Provinces of Manitoba, Ontario and Quebec. More recently, however, special investigations have been conducted in the latter province in which the insects at the present time are wide-spread and very abundant. Research work embraces the determination of the species involved, a close study of their life-histories and habits, and the conditions governing their increase and abundance, with a view particularly to reducing their damage by cultural methods of control.

#### Alfalfa Insects

The studies of insects affecting alfalfa are conducted in Southern Alberta. The investigations relate specially to the Alfalfa Thrips and other insects which check the development of the leader as well as blast the flowers. Important progress is being made in these investigations.

#### Root Maggots

The corrosive sublimate mixture for the control of the cabbage root maggot demonstrated by officers of the Branch, is now in widespread use, and injury to cabbages and cauliflowers may now be prevented by the use of this mixture. Further research looking to the control of the onion maggot has also been conducted, particularly in the Province of Ontario. This work is of a promising nature, very favourable results in the control of this insect being secured from the use of a Bordeaux oil emulsion spray.

#### Wireworms

These insects are gradually assuming a position of very great importance, particularly in the prairie provinces, and in view of this fact special investigations are being conducted in both Saskatchewan and Alberta. Interesting progress has been made in studying the habits and life-histories of these insects, which will be of value in suggesting more satisfactory methods of control.





### Cabbage Flea Beetle.

Owing to the success attending the control of this insect in the Lower Fraser Valley with a nicotine dust, the Entomological Branch recently issued an illustrated pamphlet describing this new method of control which is being adopted by the growers.

### Hop-Plum Aphis

This insect, which some years causes important injury in the hop yards of British Columbia, has been under further observation and new data regarding its life history have been secured. During recent years tests of certain dusts to destroy the aphids have been made and new types of spraying apparatus developed.

### Army Worm

Owing to the fact that in certain years this well-known destructive caterpillar suddenly appears in very large numbers causing considerable injury, special investigations have been conducted from our Strathroy laboratory in the hope that future outbreaks may be anticipated and farmers advised accordingly.

### Carrot Rust Fly

Carrot Rust Fly investigations are being conducted in the Provinces of New Brunswick and Ontario. As a result of research work of the officers of the Branch, it is now felt that this crop may be grown in the maritime provinces with a minimum of loss, provided the recommendations of the Branch are followed.

### Sweet Clover Insects

Special studies of the insects affecting sweet clover are in progress in Manitoba. The life-history and control of several insects are under study in connection with which satisfactory progress is being made.

### Tarnished Plant Bug

Intensive studies of the life-history, habits, food plants, overwintering conditions, and particularly the food supply of the spring generation, are in progress at the Ottawa laboratory.

### Timing of Field and Truck Garden Advice

In order properly to time the distribution of advice among the vegetable growers and gardeners, a study is in progress at Ottawa correlating the rate of development of crops with the appearance of the outstanding insects both in the Ottawa and other districts. The times of occurrence of outstanding incidents such as seeding, blooming, and ripening of fruit, are being checked throughout Canada. These are correlated as far as possible with the times of emergence, rates of development, outstanding incidents in insect life-histories such as egg-laying, damage and maturity, so that advice may be distributed from a central headquarters, timed to suit any locality in the Dominion.

## FOREST INSECT INVESTIGATIONS

### Lecanium Scale

This important scale insect, which has been responsible for the death of shade trees in British Columbia, has been specially studied and control measures devised which were adopted by the city of Vancouver. Usually these insects are ultimately controlled by parasites, but the latter are not as yet playing an important part in reducing the infestation.





### Spruce Budworm

This insect, which has been under investigation for a number of years, is now under special observation, particularly in the Province of Nova Scotia where airplane dusting experiments have been in progress. It is too early as yet to make any statements regarding the success of this work, but it is hoped that it will prove of value. Our recommendations for the prevention of future outbreaks include methods of forest management which will bring about a complete utilization of mature balsam fir timber so as to remove almost completely our old balsam fir stands and subsequently to utilize balsam fir before the stands become mature, and conjointly to encourage in every possible way the reproduction of spruce. An exhaustive treatise on this subject was recently published in our Bulletin No. 37, New Series.

### Bark-beetle Investigations

These investigations have been conducted for the last five years. Valuable information on the bionomics of the insect has been secured. Approximately 60,000 beetle-infested trees have been cut and burned, and the spread of the outbreaks has been checked over many hundreds of square miles - whole forests have been saved that would otherwise have been completely destroyed by the ravages of the beetles.

### The Western Cedar Borer

The seasonal history and feeding habits of this insect have been specially studied in the Province of British Columbia. As a result of these studies it is hoped that control measures of value will be discovered.

### Western Spruce Aphis

A rather interesting outbreak of this species on Sitka Spruce on the Queen Charlotte Islands was investigated by our officers in 1926. The injury appeared to be decreasing in severity. Further investigations will be made.

### Larch Sawfly

Owing to the increase of this insect in Eastern Canada further sample study plots have been established in Ontario and New Brunswick. Investigations have also been made in the Province of Manitoba. Some years ago the Branch introduced from Europe an important parasite of the Larch Sawfly. This parasite has developed in Manitoba and during the last year parasitized cocoons of the Larch Sawfly were sent to our parasite laboratory at Chatham, the parasites reared, and living specimens liberated in areas in Eastern Canada where the Larch Sawfly is developing.

### European Beech Coccus

This insect, which has gained foothold in the maritime provinces, is under special investigation, particular attention being given to its life-history and habits owing to the fact that it has not been previously studied on this continent.

### Borers in Windfalls and Logs

This project is an effort to obtain the most effective method of preventing injury to logs by the Monochamus borers - the most destructive enemies to cut timber, windfalls and fire-killed trees in our eastern woods. Very careful study has been made of the life-history of these insects and the conditions under which the attack on the timber is made.





## Spruce Chermes

Several species of these injurious insects have been studied in 1926 and additional facts discovered relating to their peculiar life histories, with alternating generations, some on spruce and some on balsam larch or pine. A new species to Canada was found in Nova Scotia, infesting the trunks of balsam fir.

## Forest Insect Biologies

Detailed studies in the bionomics of important forest insects are being conducted in the Provinces of British Columbia, Ontario and Quebec, in our British Columbia work large cages have been employed, 8 feet square and approximately 50 feet long, so that in a series of these large cages the entire tree with the cut branches has been caged and all the insects present in the trees have thus been obtained. Many important facts have been obtained which we hope will be of assistance in perfecting methods of control.

## Shade Tree Investigations

Special studies of the insects attacking shade trees are being conducted in Saskatchewan and Ontario. Important data are being secured on such well-known species as the maple leaf cutter, the imported elm leaf miner, the walnut caterpillar, the lilac leaf miner and a number of other species. The control of the Spruce Chermes was a subject of further investigation in New Brunswick, and very satisfactory control methods have been tested and approved.

## Forest Sample Plots

Periodic examinations are being made on these plots to obtain information regarding the relation between forest insects and the trees they attack. During recent years a number of new additional sample plots have been established.

## Brown-tail Moth

Since the discovery of this insect in Eastern Canada in 1907 the Entomological Branch has conducted an annual winter survey of the affected areas in order to collect the winter nests from infested trees. No sign of the pest has been seen in New Brunswick for some years. So far as Nova Scotia is concerned, it seems fairly certain that the pest is now under control, and that a continuance of the winter survey work together with provision for spraying orchards wherever it is thought desirable, would prevent the insects developing, ultimately freeing the province unless a further re-infestation from the New England States appears.

## European Pine Shoot Moth

This species recently introduced into Canada has been found at a number of widely separated places. At a number of points infested pines have been destroyed and the outbreak thus reduced. Its habits and life-history are being studied and it is hoped that native parasites from Europe may be introduced as soon as these can be secured.

## Satin Moth

This defoliating enemy of poplars and willows discovered in British Columbia in 1920 is now firmly established at numerous points on the south western coast of Vancouver Island and in the Lower Fraser Valley from Vancouver to Agassiz. A study of its life-history and natural control factors has been commenced.





### Gypsy Moth

Since the finding of this dreaded pest in 1924 the Entomological Branch in close co-operation with the Department of Lands and Forests of Quebec, has instituted a careful scouting programme which necessitated searches in areas where it was thought the insect might have gained a foothold. During recent years no new infestations have been discovered, but during the last three years the infested area in the district of Henrysburg has been sprayed with arsenate of lead as a further precaution.

## FRUIT INSECT INVESTIGATIONS

### Pear Psylla

During the last few years an extensive study of this insect has been conducted in the Niagara district of Ontario, as a result of which a new control has been effected, viz., a spray in the form of a cheap lubricating oil emulsion. A number of the larger pear growers have used this control for the third year without any injury to the trees, and with decided increase in the crop.

### Blister Mite in British Columbia

The blister mites have been under special investigation in the Okanagan Valley, British Columbia. Much new data have recently been obtained on the life-histories of these insects, observations made on their distribution and effect of the injury on different varieties of fruit. Valuable data have been secured regarding the various types of injury produced in early summer and the resultant effects of such injury at harvest.

### Oblique-banded Leaf-roller

During 1926 new important facts relating to the life-history of this insect were obtained. The natural control of the insect was also under special observation. This insect is a very destructive species, in some years causing conspicuous defoliation in apple orchards.

### Apple Maggot

A study of the life-history and control of this insect has been conducted in the Provinces of Quebec and Nova Scotia. Campaigns of control have also been inaugurated in sections where the insect is present, and as a consequence many growers have reported excellent crops as a result of the treatment recommended.

### Case Bearer of the Apple

In Quebec Province a study of case-bearing insects of the apple has been incepted. This study brought to light the presence in large numbers of a species which heretofore had been associated with the one known as the Cigar Case-bearer. Progress was made in 1926 in developing a promising control.

### Apple and Plum Curculios

These two insects which have been specially abundant in Eastern Canada, particularly in the Province of Quebec, have been under special observation, as a result of which our officers have devised improved methods of control which are being adopted by the fruitgrowers.





### Round-headed Apple-tree Borer

The life-history and control of this insect have been under special investigation in Canada. A most promising development in control was discovered, viz., the value of calcium cyanide in destroying borers working in the trees.

### Strawberry Root Weevil in British Columbia

Further investigational work, particularly in methods of control, is being conducted on Vancouver Island. This consists chiefly in testing the value of poison baits to kill the weevils. The weevil is a pest of considerable importance in British Columbia, and the fact has been demonstrated that the poison bait control is proving more satisfactory than the prevention barrier type of control.

### Budmoth of the Apple

One of the most important projects conducted in Nova Scotia is a thorough study of the budmoth affecting the apple. This investigation includes a study of the life-history and habits of the insect, as also an exhaustive study of control methods. Promising data are being secured regarding improved control methods.

### Codling Moth

This important and ever present pest of the apple is under special study in Ontario and British Columbia. Through the kindness of the United States Bureau of Entomology a small supply of Codling Moth parasites from the State of Washington was received and liberated in British Columbia.

### Oriental Peach Moth

Since the finding of this insect in 1922 in the Province of Ontario, the pest has increased to an alarming extent in certain orchards, and during the present year much damage is resulting. In the vineyards, Ont. laboratory special investigations are being conducted on the life-history and habits of the insect, and new and promising methods of control. Special observations are also being made on parasites which are attacking the insect, and for this work large quantities of infested fruit are being obtained.

### Prairie Fruit Insects

In the Province of Manitoba attention is being given to insects affecting both the wild and cultivated fruits. Progress has been made in this study, particularly in the determination of the species involved.

## MISCELLANEOUS

### European Barwig

The spread of this insect in British Columbia has been further investigated in 1922. A plan of control, consisting largely of baiting, was organized by the Branch, and for the carrying out of this the City of Vancouver appropriated \$10,000.00. The pest has spread in the environs of the City of Victoria, and in this place also a campaign of control was directed.

### Import and Export Inspection Service

In the plant inspection work carried on by officers of the Division of Foreign Pests Suppression, much research work is carried on as time permits, particularly in connection with pests which are incepted on nursery stock.





During recent years a number of important pests have been discovered on imported plants, as for instance the Gypsy Moth, Brown-tail Moth, Apple and Cherry Ermine Moths, the European Earwig, European Corn Borer, etc. As Secretary of the Destructive Insect and Pest Act Advisory Board, the Chief of the above Division has made special studies of the plant inspection laws and regulations adopted by various countries of the world.

#### Insecticide Investigations

During recent years important progress has been made in the development of new and cheaper poisons for insect control. This insecticide work is conducted particularly at Annapolis Royal, N.S. Special investigations have been made on the value of ground derris root from an insecticidal standpoint, and also of other materials which might possibly take the place of arsenical mixtures in orchard and other work. Progress has also been made in connection with certain nicotine sprays. The adoption of special localized spray schedules prepared by our insecticide entomologists has resulted in greatly improved crops and decidedly better market prices.

#### Mosquito Investigations

The importance of a study of the various species of mosquitoes has been recognised by the Branch, particularly in view of the fact that requests for advice regarding mosquito control from municipal and other bodies are increasing year by year. In the Ottawa district, for instance, working in co-operation with the Medical Health Officer, studies have been made of the more important breeding areas, the species determined, and definite instructions given as to the proper time for oiling, etc. An important report on the mosquitoes of the Lower Fraser Valley was prepared by an officer of this Branch and published by the Research Council of Canada.

#### Stored Product Insect Investigations

The life-histories of a number of important species of insects attacking flour, stored grain etc., have been studied and information published which will aid in the identification and control of adult Lepidopterous insects attacking stored products. The value of calcium cyanide as a fumigant in mills has been tested.

#### Live Stock Insect Investigations

During the year 1926 an officer of the Branch was stationed at Indian Head, Sask., for the purpose of surveying the district and making preliminary studies of insects which attack live stock under prairie conditions. Much data have been secured as a result of this project. The succession of species and the numerical proportions of the various biting flies were closely observed, and interesting data obtained with regard to the three prevalent bot flies of horses.

#### Household Insects

Further data have been secured during 1926 as a result of fumigating or superheating dwellings for the control of such pests as bed bugs, fleas, cockroaches, etc. The species of clothes moths, so destructive to coverings of furniture, woollen goods, furs, etc., have also been the subject of much enquiry, following which our officers have been able to conduct experiments and obtain data of value in future control work.

#### Greenhouse Insect Investigations

Much research has been accomplished in connection with many of the commoner species which are found in greenhouses, such as the greenhouse leaf-tyer, chrysanthemum midge, rose midge, scale insects, etc. Recently the Branch published a special bulletin on insects affecting greenhouse plants, in which much of the results of this research were published.





### Apple Sucker Disease

In the Province of Nova Scotia striking results have been obtained in introducing the Apple Sucker disease, *Mitoglyphthora sparsoporum*, into orchards infested with the apple sucker. As a result of our investigations it was discovered that the disease could be spread artificially.

### National Collection of Insects

The Canadian National Collection of Insects is now recognised as one of the most extensive and valuable collections in America. Important taxonomic studies based on material contained in the collection have been made. As a result of these studies, numbers of species new to science have been described and the types deposited in the National Collection.

### Shipments of Parasites and Predaceous Insects to New Zealand

At the request of the New Zealand Government collections of living Chrysoid flies were made in the autumn of 1925 in British Columbia and despatched to New Zealand in the hope that the species would establish itself and prey upon destructive forms of plant lice. With few exceptions the specimens arrived in New Zealand in excellent condition. Reports received in 1926 indicated that the females had oviposited and it is, therefore, hoped that this predator will survive and increase in its new environs.

### Insect Pest Review

The 'Canadian Insect Pest Review', a manuscript publication, has been issued by the Branch each month during the year. The object of the survey is to bring together all authentic records of the occurrence of insect pests in Canada, so that accurate information on their distribution and economic importance may be, at all times, readily available.



6. TRINIDAD: FROGHOPPER INVESTIGATION COMMITTEE:

INVESTIGATIONS INTO THE FROGHOPPER BLIGHT OF SUGAR-CANE IN TRINIDAD.

(The following article was compiled by the chairman of the Scientific Committee, at the request of the chairman and members of the general committee for Froghopper Investigations, for presentation at the Imperial Agricultural Research Conference.

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By F. HARDY (Chairman, Scientific Committee for Froghopper Investigation).

I.- HISTORY OF THE INVESTIGATIONS.

The earliest records which may refer to the damage done in Trinidad by the sugar-cane froghopper (*Monocophora* (*Tomaspis*) *saccharina* Dist), are dated 1862, 1869 and 1878. The insect was first identified with sugar-cane blight in 1889, but, until 1906, only small outbreaks seem to have occurred. In 1906, blight assumed really serious importance, but its severity was surpassed in 1908, 1912, 1917, 1924, 1925 and 1926. In 1917, which was perhaps the most disastrous year on record, it has been estimated that 10,000 tons of sugar were lost through the ravages of froghoppers.

From 1909 onwards, investigations into froghopper eradication were conducted mainly by the officers of the Trinidad Board of Agriculture (Urish, Rorer, Guppy), and by certain specialists (Gough (1910), Kershaw (1913), Williams (1916-1920) and Nowell (visits in 1918-1919). Up to the end of 1917, the investigation was purely entomological, and was almost entirely individualistic in its performance. The researches of Williams and Nowell, however, gave a more definitely ecological and agricultural trend to the investigation, and showed that the greatest hope of success lay in close co-operation between scientific workers of various callings and planters actually engaged in the cultivation of the sugar-cane.

In October, 1924, the Agricultural Society of Trinidad and Tobago passed a resolution that invitations be issued to the Department of Agriculture, the Board of Agriculture, the Imperial College of Tropical Agriculture (founded in Trinidad in 1922) and the Chamber of Commerce, to elect a Committee of representatives to enquire further into, and to report on, the froghopper pest with a view to its control and ultimate eradication. This committee was duly appointed, and met in December, 1924. It approved the proposals (1) that a standing Froghopper Investigation Committee be established, (2) that the services of Mr. C.B. Williams again be obtained, (3) that further entomological and agricultural experiments immediately be inaugurated, with full co-operation with sugar-estate proprietors, and (4) that a sum of £2,500 per annum for five years be provided to cover the costs of the investigations.

In October, 1925, the proposed Froghopper Investigation General Committee was appointed by His Excellency the Governor (Sir Samuel Wilson). It included the Director of Agriculture (Chairman), the Principal of the Imperial College of Tropical Agriculture, the Presidents of the Agricultural Society, the Chamber of Commerce and the Sugar Manufacturers' Association, and the Attorneys or General Managers of the Chief Sugar Companies holding estates in Trinidad. It was agreed that the Sugar Companies should provide one-half of the grant of £2,500 per annum for five years, and the Government the other half.





The first meeting was held in November, 1925. Three Sub-Committees were at once appointed to deal respectively with (1) agricultural relations (2) entomological relations and (3) soil relations. Their personnel included planters, officers of the Department of Agriculture, and members of the staff of the Imperial College. Their first duty was to submit programmes of work and recommendations.

A Scientific Committee was next formed. It included only those persons who were actively engaged in frog hopper research, namely, (Mr. W. Nowell (Assistant Director of Agriculture, Chairman), Messrs. F.W. Urich and J. de Verteuil (Officers of the Department of Agriculture), Dr. C.L. Withycombe and Mr. P.E. Turner (Lecturers at the Imperial College), and Mr. G.A. Jones (Agronomist to the Ste. Madeleine Sugar Company). Mr. Nowell was subsequently appointed a member of the General Committee. The Scientific Committee considered the reports of the three sub-committees, and made appropriate recommendations to the General Committee. These recommendations were approved, and the scientific workers were authorised to proceed with their programmes. Mr. P.E. Turner was appointed Soil Chemist to the Frog hopper Investigation Committee January, 1926. Three official observers were also appointed in that month. Since December, 1925, frog hopper investigations have been actively continued along different lines. The Scientific Committee has met on eight occasions, and the General Committee has met monthly to receive progress reports and to arrange financial and other matters. The minutes and proceedings of the various committees have been regularly published in Trinidad since December, 1925. The latest issue of the "Proceedings" is Part VI, dated April, 1927.

A change in the composition and plan of work of the Scientific Committee followed the promotions in July of Mr. Nowell and of Dr. Withycombe to posts abroad. The Chairmanship of the Scientific Committee was committed in August, 1927, to Mr. F. Hardy (Professor of Chemistry and Soil Science at the Imperial College), and Mr. F.W. Urich was appointed Secretary. Dr. Briton-Jones (Professor of Mycology at the Imperial College) had previously been elected a member of the Scientific Committee. Mr. R. Follett-Smith was appointed assistant to Mr. Hardy, and later, a member of the Scientific Committee. Mr. E.B. Smith, of Woodford Lodge Estate, was also appointed a member of the Scientific Committee.

Numerous articles have been published in the "Proceedings" by members of the Scientific Committee and others. These, and the Minutes of the various meetings, including monthly progress reports, indicate the trend of the later work.

## II.- PROGRESS OF THE INVESTIGATIONS.

### (A) Entomological Phase.

(1) Life History. - The life history of the Frog hopper (*Monecophora* (*Tomaspis*) *saccharina*, Dist.), a typical cercopid insect, indigenous to Trinidad, has been fully described by Urich, Guppy, Kershaw and Williams. The eggs are laid in dead basal leaf-sheaths of the cane-plant, or of other grasses, in moist soil, and in dead cane-leaves (trash) that have been heaped together as "boucans" in the fields. They hatch under suitable moisture conditions in about two weeks. The nymphs develop in four instars, and live on cane or other grass roots. They excrete fluid matter, which they inflate into froth. They cannot penetrate into soil except through cracks. The nymphal stages occupy five or six weeks.





Adults feed by piercing and sucking cane-leaves or other grass leaves during the evening and night. By day, the adults hide in cane-leaf axils. During feeding, the adult voids liquid at the rate of about 1 cc per 24 hours. Blight may or may not follow sucking, chiefly depending apparently, on the "condition" of the leaf. No variety of cane shows special powers of resistance, but the Uba cane shows strong powers of recovery. Ratoon canes are more susceptible to blight than plant canes. Tissue discoloration and disintegration account for blighting, which takes the form of yellow or brown leaf streaks. When extensive and contiguous, these may occupy the whole leaf area. The blighted cane-plant may die, or may suffer a more or less severe set-back in growth. Many characteristic morphological features accompany blighting (adhering dead leaves, shortened internodes, abundant aerial nodal roots, &c.).

Adult froghoppers may live as long as four weeks. Under normal wet-season conditions, the whole life cycle generally takes about two months to complete.

In Trinidad cane-fields, three or four broods of froghoppers are often experienced. The first brood emerges at the onset of the wet season (late May or June). The second brood (usually the largest), appears in late August or September. The third brood which is less definite, appears in October to December. The fourth brood is rare and ragged. It occasionally appears in December and January. During a typical dry season (January to June), the froghopper occurs in cane-fields almost entirely in the aestivating egg stage. Abnormalities in the intensity of the seasons produce variations in intensity of froghopper incidence. Wet dry-seasons encourage hatching, and continue the exposure of the insect to enemies which may have gained in numbers during the preceding wet season. Blight in such years is usually not very severe (e.g., 1905, 1910, 1914, 1915, 1916).

(2) Eradication.-- Various suggestions have been made for destroying the froghopper during one or other of its life stages. So far, however, these suggestions have not been put into wide operation by planters.

Eggs in cane and grass leaf-sheaths can be destroyed by stripping off the cane leaves (trashing) and transferring them from the fields to stock pens, and by weeding the fields at the correct time. These practices are not generally favoured. The advantage of burning the trash off the canes is offset by its destruction of parasites and enemies, and loss of soil organic matter. Spraying with ovicidal liquids has not proved satisfactory. Trials of ovicidal dusts have not yet passed the laboratory experimental stage, but results so far obtained are promising.

Nymphs resist most spray liquids because of their covering of froth. Various liquids were tried by Gough, who concluded that kerosene emulsions alone were worthy of further trial. Some success was obtained last year by Briton-Jones with "Flit" emulsion. Spraying, however, involves the use of cumbersome apparatus, it is costly, tedious and slow. Furthermore, it requires an abundant supply of water at a time when water is usually scarce (at the beginning of the wet season). Perhaps hand-sprayers may overcome some of these difficulties. Recently, dusting with "Cyanogas", first suggested by Urich), has proved effective in destroying nymphs under estate conditions. Follet-Smith and Hardy report 80 per cent. destruction at reasonable cost in three large-scale field trials conducted in 1926. "Cyanogas" dusting



by hand-dusters is to be tried on sugar-estates this year (1927), if nymphs appear in sufficient numbers to warrant its performance. Orders for some 79,000 lb. of "Cyanogas" powder have already been placed by estate managers. On some estates, crushing the nymphs with sticks, and hand collecting have been tried, but the labour requirement is great and the method cannot be expected to cope with large outbreaks.

Adults have also been collected by hand, but not economically. Spraying has been tried. Dusting from aeroplanes has been suggested by Withycombe. The use of "Cyanogas" dust mixtures applied to adults hiding in the cane-leaf axils will be tried when opportunity arises, as it is thought that this method promises some measure of success. Light-traps have been recommended by Williams and E.B. Smith. Properly used, they may yet prove satisfactory. At least they may be useful in indicating the occurrence of broods. The encouragement of natural enemies, such as certain birds, lizards, toads, frogs, and egg-parasites, has been favoured, and some attempt is being made to foster useful birds by acts of legislation and by establishing bird sanctuaries. Destruction of mongoose (a secondary predator thought by many to be responsible for the increasing paucity of birds), is at present being actively encouraged by payment for carcasses. The requisite funds are being provided partly by sugar planters and partly by a Government grant.

The introduction of new enemies of the froghopper was thoroughly considered by Williams and Ulrich, but because the pest is an indigenous insect, it is generally admitted that not much hope lies in this direction. In order that any introduced parasite may become effective, it would have to establish itself in spite of the presence of numerous local hyperparasites. Furthermore, it must be able to withstand the dry season, at least as well as the froghopper.

(3) Prediction of attack.— The usefulness of a practicable method of predicting where and when an attack of froghoppers may occur, needs no stressing. Ulrich collected old cane-stools from fields that had been reaped in the dry season of 1925, and put them under suitable conditions of moisture in the laboratory. Eggs hatched normally, and the degree of infestation of each stool could be assessed by counting the nymphs in spittle. The method was applied on a limited scale for recording egg-distribution on sugar-cane estates by collecting four or five stools per field. It proved impracticable for rapid field work, however, because of the difficulties of transport and the tedium of digging. It was subsequently proposed that dug-up stools be accumulated and kept moist under tarpaulin along borders of fields instead of in the laboratory.

At Waterloo Estate, a stool-shaving machine, such as is used in Louisiana for paring-off stumps of cut cane-stools as a preliminary to earthing them over for lessening water injury, was found to yield shavings containing large numbers of froghopper eggs. This discovery caused Ulrich to devise a useful method of field-testing for froghopper eggs intensity and distribution during dry seasons. The method consists in chipping-off the exposed ends of four or five representative stools of cut-canes in selected fields, by the use of a carpenter's adze. The chippings are labelled and put into shallow water-containing tins or earth-trenches located at some convenient centre. Periodic examination enables counts





to be made of hatched eggs. The results are plotted on estate plans. The method is being applied this year (1927) at three estates, and is yielding satisfactory results.

(4) Recording blight-spread. - Novell introduced a statistical method for following the spread of blight caused by successive frog hopper broods, in which periodic records of affected fields are set down on special sheets by planters or overseers. The sheets are sent to head office for tabulation and filing. The method is proving rather unwieldy, through delays in the filling-in and collection of record sheets.

Last wet season (1926), E.B. Smith introduced a simple cartographical method for recording on estate plans the spread of blight by marking in colours fields affected at the end of each month. The method was successfully applied to four estates, and is to be employed in more elaborate detail during the coming wet season.

#### (B). Mycological Phase.

The decrease in numbers of frog hoppers comprising the later broods, is usually ascribed to their being overtaken by various enemies and parasites, which develop rapidly during the wet season. Particular significance is attached in this relation to two entomogenous fungi, namely, the Green Muscardine fungus (Metarrhizium anisopliae, Sorokin) and the Empusa fungus (Empusa sp.)

Green Muscardine was first noted by Hart. in 1889. It is capable of killing its host in two to six days. Occasionally it attacks nymphs. It is stated that gravid females, killed by the fungus, have repeatedly been observed in the field. The question whether or not Green Muscardine is able to destroy healthy gravid females, and not merely females debilitated by age or other cause, is being critically examined by Briton-Jones.

Rorer in 1909, Gough in 1910, and Williams in 1918, attempted to produce spores of Green Muscardine in quantity, by growing the fungus on starchy media. They devised various means for distributing the spores in cane-fields. The most practicable method appears to be that in which light-traps, furnished with trays containing spore material, are employed to attract adults. The adults carry away fungus spores and thus effect their dissemination. The whole subject is being re-examined by Briton-Jones.

Empusa appears later (October to January) than Green Muscardine, and is less common. It is a more specialized parasite, and seems to be more sensitive to external conditions.

Root diseases of sugar-cane, of the Marasmius and the Odontonia type, may cause complications in the phenomena of blighting. Williams concluded that frog hopper attack is the main predisposing cause of rapid spread of root fungi in cane-fields, and that fungus infection may result in greater injury to the plants, and in lessened ability to recover from blighting.

#### (C) Agricultural Phase.

Whilst practicable and economical means of eradicating frog hoppers by the employment of insecticides are highly desirable, it is generally agreed that the solution of the frog hopper problem ultimately lies in improvements and modifications in existing agricultural practice.





Various recommendations have been made by different workers at different times, but so far, most of them have proved either agriculturally or economically unfeasible. The main proposals may be enumerated as follows :-

(1) Better drainage. - All planters admit the desirability of better drainage, especially on the low-lying, flat, alluvial lands of the Central and Northern plains. It is often difficult to get a proper fall and suitable outlets. Even when surface water is adequately dealt with, subsoil water shows little tendency to move in many of the heavy impervious clays. Consequently, many lands are water-logged for a great part of the year. The advantages and disadvantages of the various ways in which draining-trenches may be arranged and dug, and beds built and planted in Trinidad need not here be discussed. The whole subject is receiving increasing attention from planters, especially since the possibilities offered by agricultural implements were realized.

(2) Rotation of crops. - Crop rotation is not usually practised in Trinidad. Sugar-canes, grown from cuttings, are reaped at the end of a year or eighteen month's growth, and are then allowed to ratoon for one, two, or more crops further. Sometimes the fields are abandoned to grass and weeds when their productivity falls. No reasonably profitable rotation crop or intertillage crop has yet been discovered for Trinidad, unless it be the Bengal Bean, which recently has come into prominence because of the increasing demand for nitrogenous seeds for cattle food in northern countries. The climate and soils of Trinidad cane-lands are not quite suited to many tropical rotation crops, such as truck crops and cotton, and labour conditions make difficult the satisfactory cultivation of plants such as hemp. Nevertheless, widespread attention is being paid nowadays to the fuller use of intertillage crops such as Canavalia, Sunn hemp (Crotalaria juncea) and pigeon pea (Cajanus indicus).

The main advantage of rotation in relation to the frog hopper problem, is that rotation crops can be employed to separate cane-fields, and thus to reduce the risk of rapid spread of adults, which are believed to move mainly by drift rather than by flight. Fields of grass, and abandoned cane-fields, as well as grassy traces, harbour frog hoppers, and furnish suitable aestivating grounds for eggs.

These facts are nowadays thoroughly appreciated by most cane-planters in Trinidad, and doubtless agricultural practice will gradually be improved to cope with them. It is debatable, however, whether serious curtailment in ratooning, as has recently been advocated by Briton-Jones, will come about, until labour conditions prove more satisfactory.

(3) Manuring. - Most estates realize the great value of organic, humus-containing manures in sugar-cane agriculture, and greater attention is nowadays being given to this matter than ever before. The "Adeo" process, the Mauritian pen system, and the distillery-sludge method of converting cane-trash, waste grass and herbage into organic manures, are each being actively tested by planters, working in close conjunction with laboratory investigators. Fertilizer salts, with the possible exception of sulphate of ammonia, are not used in any great quantity at present, but doubtless their value will be fully appreciated when soil conditions have been improved by other, more fundamental, means.



Unfortunately, the practice of burning-off dead cane-trash from plants about to be reaped is considered necessary in fields where the Uba cane is grown, for this plant does not naturally shed its dead leaves. Willful malicious burning is rightly deprecated, and stern measures are taken to prevent it.

(4) Liming. - The question of liming is discussed under the heading "Bio-chemical Phase."

(5) Irrigation. - Irrigation is not practised on Trinidad sugar-cane estates. It is not altogether impossible for estates lying within easy access of the rivers rising in the hills of the Northern Range, but it would be expensive. Enquiries are now being made as to its feasibility. There is no doubt that the cane-crop in Trinidad would benefit greatly by careful irrigation during typical dry seasons, when the plants usually suffer from drought. Drought-stricken plants appear to be less able to resist the ravages of froghoppers when the wet season rains arrive, since there is no time for them to rejuvenate before the first brood adults emerge.

An interesting experiment was initiated by Mr. L.A. Grant, Manager of Caroni Estate, in the dry season of 1926. Water from a factory skimming-drain was diverted so as to irrigate some 100 acres of cane-land lying in a bad froghopper area. Observations showed that the irrigated canes suffered much less severely from blight caused by first and second brood adults, than did neighbouring canes growing in unirrigated fields, although they were rather badly blighted by third brood adults. The experiment was to be tried again on a larger scale during the present year, and a similar experiment was contemplated for another estate (Orange Grove) but the continuation of abnormally heavy rains during the present dry season, rendered these further experiments impracticable.

(6) Flooding of fields. - In quite another connexion, the flooding of cane-fields at the commencement of the wet season has been advocated by many authorities. The reason favouring the practice is that flooding might cause froghopper eggs to hatch regularly, and might subsequently drown or drive the nymphs up the canes and grass-stems, where they may not be able to feed, or may be destroyed by natural predaceous enemies, or may be easily exterminated by insecticides.

The advocated method of flooding consists in temporarily blocking up field-drains, so that the early rains are collected. There is some evidence that the desired results actually are achieved in areas where submersion occurs naturally when low-lying rivers overflow their banks. Experience in British Guiana apparently supports the contention, for in that country, froghoppers are known rarely to increase in sufficiently large numbers as to become a serious sugar-cane pest. Nevertheless, the parallel is not strictly logical because, in British Guiana large areas of land lying below the level of irrigation canals are artificially flooded at one and the same time as a common routine agricultural procedure, whereas in Trinidad, it would be difficult to flood comparatively extensive areas of land within the short space of time necessary to achieve success. Furthermore, difficulty might be experienced in subsequently draining off the water. Critical experiments to test the flooding theory are being devised for application when suitable conditions arise.

(7) Treatment of traces. - Undisturbed grassy traces bordering cane-fields have long been known to harbour froghoppers, and to furnish breeding grounds for adults during the dry season. Their suitable treatment is a difficult practical problem. Many estates depend for stock fodder on





grass grown in these traces. Carting during the dry-season when pen-manure is being spread and the cane-crop hauled off the land, may disturb froghoppers residing in the centres of the traces, but the borders, banks and ditch-sides are still left untouched. Nevertheless, several planters are attempting to cope with the problem by cutting grass with mowing machines, or by growing leguminous or other non-gramineous plants along the trace borders. Clean-weeding by the use of road-grading implements is being attempted on some estates.

(8) Treatment of thrown-out fields. - The question of how best to deal with thrown-out fields which often become grassed-over and harbour froghoppers before they are replanted, is similar to that described in the last section. Ploughing during the dry season, as soon as the crop is removed, so as to turn up and expose old cane-stools, has been advocated as a means of destroying froghoppers in the egg or nymph stages in such fields, but its efficacy has not yet been definitely estimated by controlled experiment.

Various ovicides are being tested with a view to their suitability for use on thrown-out fields and ratoon fields, but the tests have not yet passed the laboratory stage. The growing of suitable fodder-crops, catch-crops or rotation-crops, would of course, help to solve the problem. They have already been considered under another heading.

#### (D) Bio-Chemical Phase.

##### (1) - Insect and Plant.

Withycombe studied the mechanism of sucking and its effects on leaf tissues. Sucking is preceded by salivary expulsion. Froghopper saliva contains, according to Withycombe, diastase and oxidases, but no invertase. Its specific enzyme content may account for the rapid disintegrating action which it exerts on border parenchyma cells and on phloem cells, whose saps possess approximately the same reaction as that at which diastase exhibits greatest activity (pH 4.4). The phloem tissue of damaged leaves becomes blocked with red oxidation products of tannins. Translocation of nutrient substances is thereby arrested; water deficiency due to adverse environmental conditions to which the plant may be exposed, is stated to prevent recovery of affected cells, and desiccation of leaf material may result.

Inoculation experiments, as far as they have been tried, indicate that the froghopper is not the vector of a disease organism which might be the actual cause of these changes, so that the ultimate injury appears to be a general upset of the metabolic processes of the cane-plant, caused by injection of enzyme-carrying saliva into its leaf-tissues.

##### (11) - Plant and Environment.

Both Williams and Withycombe consider that the water relations of the cane-plant are of chief importance in connexion with retardation of the local spread of injurious effects of froghopper attack and recovery from injury. They adduce field, greenhouse and laboratory evidence in support of this contention. Williams believed that the most important factor determining prevalence of blight is humidity of the environment immediately above and immediately below ground surface. He states that (1) extreme dryness in the dry season, (2) dry weather in the wet season, and (3) very wet weather in the wet season tend to increase blight, whereas (4) wetness in the dry season tends to reduce blight. Climatic records certainly seem to bear out these generalisations.





In order to test the effect of the various environmental factors on the prevalence, severity and recovery from blight, Hardy, in September, 1926, initiated plot experiments at three climatic stations, namely, Caroni, Waterloo and Petit Morne Estates. At each station, two half-acre plots were selected by the managers in charge. The pairs of plots supported canes of the same variety at the same stage of growth, and subjected to the same cultural treatment. One plot of each pair was selected within an area where canes usually suffered from blight ("bad" plot) and the other, within an area where canes usually did not suffer greatly ("good" plot). At each station, daily records are being kept of meteorological conditions, and weekly records of soil moisture and cane-leaf moisture. Periodic soil and leaf samples are also being collected for chemical and physical analysis. The experiment has not continued far enough for definite conclusions to be made, but it is believed that this dynamic method, if applied over a number of years, will furnish significant evidence of the importance of environmental fluctuations in particular relation to water supply.

The soil relations of the cane-plant have long been suspected of being of fundamental and even critical importance. Williams refers to many instances where soil conditions seem to be the controlling factor in susceptibility or resistance of the cane-plant to froghopper blight. The most striking example is afforded by two contrasted soil-types displayed on the lands of the Usine Ste. Madeleine estates. The one is a friable, black, humic, calcareous, marl soil, which supports vigorous cane-crops that seldom get blighted, even in seasons when froghoppers are very abundant. The other is a heavy, impervious, light-red, acidic, clay soil, whose cane-crops, at least in the ratoon stages, generally suffer severe froghopper injury. Instances of freedom from, and liability to blighting are also afforded in other less clearly defined soil-areas within the more uniform regions of the central and northern alluvial plain where the majority of the sugar estates are situated.

A particularly striking example revealed itself during the detailed examination of the soils comprising the "good" and the "bad" observation plots at Caroni Estate. The soil of the good plot was found to be calcareous and highly alkaline in reaction. ( $\text{CaCO}_3$  content 0.5 per cent., and pH 7.6), even at a depth of  $2\frac{1}{2}$  feet, whilst the bad plot was lime-free and acidic (pH 5.9). The good plot yielded, per acre in March, 1927,  $23\frac{1}{2}$  tons of ratoon canes that had not suffered appreciably from blight, whereas the bad plot yielded only  $3\frac{1}{2}$  tons per acre of badly blighted canes. The two plots are only one-hundred yards apart, and have received the same cultural treatment. The alkalinity of the good plot soil is traceable to heavy and repeated covering of wind-blown, limestone road-metal dust from an adjoining main road. The effect of limestone road-dust in imparting resistance to blighting to canes growing along the margins of certain fields, may be noticed in various districts in Trinidad.

On the other hand, liming has been practised as an agricultural operation on certain estates for years past, yet without marked beneficial effect.

In order to explore the whole subject, an intensive soil survey of Trinidad cane-lands was initiated by Nowell and Hardy in 1926, and rapidly extended by Hardy in 1927. The work received enthusiastic support from sugar planters, and the Froghopper Committee provided funds for the appointment of a special soil chemist (P.E. Turner), and of numerous laboratory assistants, and for the purchase of necessary apparatus. Accommodation and equipment were



furnished by the Imperial College, where the soil work is now being prosecuted.

So far, some 1,400 soil samples have been collected by a fork-and-trowel method. They cover a large range of the main cane-soil types of the Island. Texture is being measured by determinations of three physical constants, namely, (1) moisture at point of stickiness (2) percentage fine and coarse sand, and (3) hygroscopic coefficient. From these, "indices of texture" are calculated, and the numerical results are plotted in colours on estate maps.

Soil reactions have been determined on nearly all the samples by means of the quinhydrone electrode, checked by Comber's thiocyanate reagent. The rapid elaboration of soil-reaction maps is rendered possible only by the ease and facility with which these new methods can be applied. Specially selected soil samples are being examined by Turner, employing modern methods of base-exchange measurement.

So far, the reaction determinations have suggested that most of the lime that has been applied in the past to Trinidad cane-soils has not reacted properly with the soil components. Few of the limed soils possess a "normal" alkaline reaction, and fewer exhibit an "exchange" alkaline reaction.

Of the total number of soils examined, only 13 percent. possess normal reaction values above pH 7.0; whereas 28 percent. possess reactions between pH 7.0 and 6.0, 49 per cent. reactions between pH 6.0 and 5.0, and 10 percent., reactions between pH 5.0 and 4.0.

Of the alkaline soils (13 percent. of the total number of soils), 53 percent. were derived from natural marl, and 16 percent. are road-side soils. The rest (51 percent.) owe their alkalinity evidently to liming. Three-fifths of the limed, alkaline soils, however, were obtained at one relatively small estate (Orange Grove), the only estate where liming has been practised at all extensively and persistently.

Only about one-half of the alkaline soils of Trinidad possess "exchange" alkalinity, and the majority (85 per cent.) of these are either natural marl soils, roadside soils, or soils from the one estate (comprising sandy soils) that has been extensively limed. This therefore confirms the view that liming in most instances has not yet had much effect, particularly on the heavier, water-logged clay lands, which probably ought to be thoroughly drained and tilled before further liming is attempted.

#### Correlation between soil reaction and blighting.

Recent field observations and records (in part contrary to the earlier results of de Verteuil and of Withycombe, who used less precise colorimetric methods for measuring soil reaction), so far indicate a striking positive correlation between alkalinity of soil and relative freedom from blight. Almost all the natural marl soils and many of the road-side alkaline soils, support canes that show little or no blighting, even in severe years. On the other hand, almost all soils of reaction more acid than pH 5.5, support canes that are so severely damaged in bad froghopper years, that they yield practically no ratoon crops at all.

The application of base-exchange methods should aid in giving greater definition to this suggested correlation, but the work has not proceeded far enough to warrant final conclusions at this juncture.





It is interesting also to note that recent re-determinations of pH values of the special soil samples collected by Williams in 1921, and by de Verteuil in 1921-1926, rectify most of the discrepancies that were revealed when attempts to correlate soil reaction with frog hopper blight were made in the early days.

It is not unreasonable to suppose that soil reaction may well be a fundamental factor governing susceptibility or resistance of the cane-plant to frog hopper blight, since it is now widely recognised that hydrogen-ion concentration of the soil environment, and the physico-chemical composition of the soil, largely control the intake of water and of various nutrients (particularly potassium), by plant-roots, and that both water relations, and the chemical composition of plant-sap play important rôles in deciding the behaviour of plant-tissues when subjected to disturbing influences such as insect attack. (vide Andrews (3)). Herein may indeed be the link connecting the water relations between soil and plant, which has been stressed by previous workers. Bio-chemical work now in progress, on the composition of leaf-sap and leaf-ash of cane-plants growing on various types of soil at various seasons of the year, should yield definite information on the other question.

We have already noted that irrigation in a severe frog hopper year brings some relief from blighting. This observation falls into line with the foregoing suggestions, for, other things being equal, cane-plants maintained in more vigorous growth by adequate water-supply, would be expected to be more capable of resisting or throwing-off frog hopper ravages than plants suffering desiccation.

#### Conclusion.

The considered opinion of Nowell expressed in a special memorandum written by him for presentation at the first meeting of the newly constituted General Committee in November, 1925, appears still to hold, and may here be recited.

"The general conclusion indicated is that an  
"agriculturally imperfect condition of the soil,  
"from whatever cause it may arise, is favourable  
"to the development of frog hopper infestations in  
"years when the general climatic conditions are  
"suitable."

#### R E F E R E N C E S:

(1) C.B.WILLIAMS:- "Report on the Frog hopper Blight of Sugar-cane in Trinidad." Memoir I of the Department of Agriculture, Trinidad and Tobago, January, 1921. (Contains a full summary of the work of Ulrich, Rorer, Guppy, Hart, Collins, Gough, Kershaw, Nowell and Williams, up to the end of 1920.)

(2) C.L. WINTERKOMB:- "Studies on the Aetiology of Sugar-cane Frog hopper Blight in Trinidad." - I. Introduction and General Survey Annals of Applied Biology, XIII, 1 February, 1926.





(3) E.A. ANDREWS.- "Factors affecting the control of the Tea Mosquito Bug." Indian Tea Association, 1923.

(4) Minutes and Proceedings of the Froghopper Investigation Committee, Trinidad, Pt. I, Dec., 1925; Pt. II, Apr., 1926; Pt. III, Aug., 1926; Pt. IV, Oct., 1926; Pt. V., Jan., 1927; Pt. VI. Apr., 1927, pp. 1-177.- (Contains notes and accounts of the work of Urich, Nowell, Withycombe, Ashby, Briton-Jones, Turner, de Verteuil, G.A. Jones, E.B. Smith, Follet-Smith and Hardy.)"

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7. BARBADOS: NOTE ON A COOPERATIVE SCHEME FOR COLLECTION  
AND DISTRIBUTION OF PARASITES OF INSECT PESTS. THE  
CONTROL OF INSECT PESTS BY MEANS OF PARASITES.

The economic value of parasites in controlling insect pests has been convincingly demonstrated by the results of the introduction of parasites into Hawaii. The following quotation is taken from a summary of the work of the Convention of Sugar Cane Technologists, published in "Facts About Sugar" of the 26th of March, 1927. "Mr. Hamilton P. Agee of Hawaii held the "close attention of the technologists with an address on the "control of pests by parasites that was one of the most "instructive features of the Convention. He reviewed the work "that has been carried on in Hawaii during the past twenty-five "years, and stated in conclusion that while hundreds of thousands "of dollars had been spent in obtaining parasites to overcome "pests, any one of the three major successes had paid for the "work over and over again. The three major successes referred to "were the finding of parasites to overcome the leafhopper, the "weevil stalk borer and the larvae of grubs of the anomala beetle "introduced from Japan".

The serious insect pests of the sugar cane in Barbados are the moth (stalk) borer, Diatraea saccharalis, Fabr., the root borer, Diaprepes abbreviatus, Linn., and the brown hardback (root-borer) Phytalus Smithi, Arrow.

Of Diatraea saccharalis there is a parasite, Trichogramma minutum, Riley., which deposits its eggs in the eggs of Diatraea. Mr. Harold E. Box, an Entomologist trained under Maxwell Lefroy of the Imperial College and at Imperial Bureau of Entomology, London, who has had experience in Africa and British Guiana, and who was employed as Entomologist by the Aguirre Sugar Co. of Porto Rico and is now Chief of the Division of Entomology of the Tucuman Experiment Station in the Argentine Republic, has made a study of insects (tachinid flies, wasps, etc.) parasitic on insect pests of the sugar cane, especially those attacking the moth borer. He contributed a paper to the Convention of sugar Cane Technologists in Havana in which he advocated an international scheme of co-operation between Agricultural Departments in order to maintain a staff of Entomologists for the purpose of visiting all cane growing countries and studying therein the parasites of sugar cane insect pests.

He studied the parasites of Diatraea saccharalis in Venezuela and British Guiana, and recently brought to Barbados a few hundred wasps Ipobracon grenadensis, Ashm., and Microdus sp., and demonstrated to the Agricultural Society of Barbados the remarkably active and effective manner in which they did their work of paralyzing, and depositing their eggs in the larvae of, the moth borer. As a result we have arranged for shipments of cages of these wasps at intervals from British Guiana, with a view of breeding and distributing them over the Island of Barbados.

Parasitic on Phytalus Smithi, Arrow., is the wasp Tiphia parallela, of which the adult obtains its food from the nectar secreted by glands on the leaves of the shrub. Cordia interrupta, DC. Prod., and which deposits its eggs underground on the larvae of Phytalus while it is attacking the roots of the sugar cane.





No parasite of Diaprepes abbreviatus, Linn., is known, but Mr. Box suggests that such a parasite may exist in Santo Domingo where Diaprepes exists and is kept in check.

It has been estimated that in Barbados at least 30 per cent. of the sugar cane crop is sacrificed to insect pests and the subsequent attack of fungi, so that if the average sugar crop of Barbados at the present price of sugar is worth £1,200,000 then £500,000 is lost through the depredations of insects.

The sweet potato, Ipomoea Batatas, is the most important of the food crops, in Barbados grown for local consumption. It is, alike beneficial to the planter to whom it affords a valuable catch crop, and to the labourer and population generally to whom, when abundant, it supplies a cheap starch food. Unfortunately, over an increasing area of the Island, it is becoming unprofitable to plant the sweet potato because of attacks of the scarabee beetle, Euscepes batatae, which often completely ruins the crop.

No parasite or natural enemy of this pest is known to us in Barbados, and the finding of such a parasite which keeps the pest in control, in countries where both the parasite and the beetle exist together, would be of great value to Barbados.

The object in presenting this note to the Conference is to suggest for discussion the advisability of the Empire Agricultural Departments co-operating together to establish a staff of travelling Entomologists for the purpose of studying the parasites of insect pests and of transmitting those parasites to parts of the Empire that need them.

These Entomologists might also arrange for the transmission of supplies of seeds of any plants, like Cordia interrupta, that are necessary to supply food for the adult forms.

The cost of such a co-operative undertaking should be borne by contributions from the different participating Governments, in the case of sugar cane pests the amounts of the contributions being proportional to the output of sugar.





8. NYASALAND. THE NEMATODE WORM AS A MAJOR PEST  
OF TOBACCO.

For some years past Nematode attack has been one of the most serious problems associated with tobacco growing in Nyasaland and there is evidence that the losses caused by this pest are on the increase. The reduction in the yield of affected plants amounts in the aggregate to a large tonnage and naturally has an adverse influence on the profit per acre.

Preliminary observations on the pest indicate that elaborate and intricate work is required before satisfactory lines of control can be formulated, and it is suggested for the consideration of the Imperial Agricultural Research Conference that an exhaustive investigation of nematode attack under field conditions in the tropics would prove a most valuable subject for research work.









